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BIOLOGICAL BULLETIN.

NOTES ON THE STRUCTURE AND DEVELOPMENT OF EMBIA TEXANA.

AXEL LEONARD MELANDER.

Delays in the spring rains of 1902 made Pease Park at Austin, Texas, an unusually good collecting ground for the entomologist during the early summer. Numbers of rare and interesting insects were flying about the *Sapindus* and *Eisenhardtia*, plants which grow profusely there. The now-running Shoal Creek had its share of swarming Ephydridæ. On the open ground in the cedar brakes several ants and a number of Microhymenoptera belonging to genera new to this country were obtained. In the midst of this profusion of insect life we were not greatly surprised on turning over a chance stone to discover the male of *Embia texana* on May 10. This was soon followed by the other forms of the species, so that now we are able to throw some light, at least, on the transformations of these insects.

The question of the sexes of these insects has long been an enigma. Owing to the fact that many of the species were taken in abnormal situations, as on exotic plants imported by nurserymen, but little has been brought to light regarding their habits. Winged, half-winged and wingless specimens of the different species have been taken. Even after dissection the winged ones were affirmed to be females in some species and males in the others. The nymphs were once supposed to be micropterous adults, corresponding with the neoteinic royal forms of the Termites. Of the wingless casts, some had the symmetrical abdomen of the female (larvæ and adult females) and some the asymmetrical genitalia of the male. Inasmuch as a complete series of practically but one of the species has been obtained, and this form has not been altogether correctly interpreted, it is not surprising that this disagreement existed.

The fortunate discovery of all the forms of the American species reveals the fact that the Embiidæ may be polymorphic. During the winter and spring our species exists in the larval state, with occasionally a chance female surviving the summer and living into the autumn in the same nest with her young. In early May the final moultings occur. At that time the larvæ destined to become females increase rapidly in size, and with the final moult their reddish mottled color becomes a dark chestnut brown or even a bronzed black posterior to the prothorax. No traces of wings are evident nor is there a lengthening of the antennal joints. The abdomen of the female retains the symmetrical termination of the larva, is covered apically with longer and denser hairs, the last ventral becomes longitudinally split, and the cerci remain each two-jointed and short. These large females are sluggish in movement, carrying the abdomen with a dorsal hump as does the larva. They still spin their web-nests with glands unaltered during their metamorphosis. They are often social and frequently live two or three in a nest, whereas but a single male develops out of a brood of larvæ. The same fact

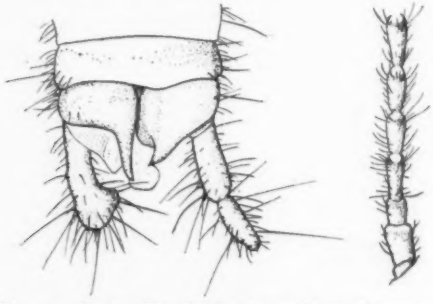

FIG. 1. *Male.* Tip of abdomen, and base of antenna.

has been observed in the case of *insularis*. However, in all collections of the Embiidæ the females seem to be much the rarer sex.

With the male the metamorphosis may proceed in one of two ways, *i. e.*, the males of *texana*, and of other species also, are dimorphic. At the penultimate moult wings may be formed, as in the Orthoptera, or not. In the former case a true nymph-

stage is attained. The body is but little larger than the full-grown larva, still of a pale reddish color, and marked with the same designs of irregular pigmentation. The antennal joints have the same magnitude and the cerci are two-jointed. Like the larva and adult female the abdomen is carried with the end bent down. The conspicuous change undergone at this moult is the acquirement of wing-pads. These are outgrowths from the anterior and lateral angles of the meso- and metathorax, which are folded over the dorsula, meeting in the median line, and attached by the basal part of their inner margin to the thorax, as in all true Orthoptera, and not as the misleading figure by McLachlan[1] would indicate. This stage has been observed in *insularis*, *Michaeli* and *Uhrichi*. Nymphs of *mauritanica* also have been found by Mr. Nathan Banks on date-palms imported from Algeria to Washington, D. C. The nymph-stage is of short duration, lasting probably not more than a week. Towards the end of that time the outer cuticle begins to separate. The single-jointed left cercus can be seen through the loosened chitin, extending into the second joint and reminding one of the figures of the Forficulid *Dyscritina*.[2]

With the last moult the habitus of the insect changes surprisingly. Full pigmentation and chitinization soon set in and the body becomes jet black with a bronzed tinge. Instead of the cylindrical form of the larva, the abdomen becomes depressed, and is now carried with the tip curved high over the back, altogether different from its former behavior. The front legs become inactive, and except during excitement, are never used for locomotion, being held helplessly in front of the body. The spinning glands of the front metatarsi do not cease to be functional, for the males were observed to spin, though always in a reluctant manner. The antennal joints lengthen, giving to these organs an increase of one half their former extent. The wings now become large, exceeding the tip of the abdomen, and also acquire their full pigmentation and villosity. When not in use they are carried flat over the back. As has been noticed for the other species the wings are attached firmly to the thorax and are

[1] *Jour. Lin. Soc. London*, XIII., Pl. Fig. 2*a*.

[2] See Green and Burr, *Trans. Ent. Soc. London*, 1898, Pl. XVIII.

in no manner deciduous. Hence the wingless male described below cannot be considered as a dealated form. Herewith is given a more detailed characterization of the male. Aside from the description of the wings it will apply for the wingless form mentioned later on.

EMBIA TEXANA Melander.

Male.—Length 6 mm., length of antenna 3 mm., length of wing 4.5 mm. Clear-cut, slender species. Body black, with violaceous or bronzed reflection; head, prothorax and front femora castaneous brown, middle and hind legs sometimes also brown, but darker; black-villose, the hairs variable in length and number. Antennæ black, the individual joints pale on their outer fifth, seventeen joints present, and these equalling a little more than one half the body-length, *i. e.*, reaching to the end of the metathorax, basal joint stout, cylindrical, a little longer than wide, second joint of less width, quadrate in profile, the remaining joints elongate-pyriform becoming elliptical terminally, the individual joints about as long as the basal two; all the joints are provided with stiff radiating black hairs. Palpi of same structure as in the larva, the maxillary palpi black, the labial reddish at the base. The lighter spaces of the head and thorax of the larva are much altered, becoming faint and indefinite in the adult. Propleuræ with two small sharp black tubercles in front of the coxæ. Thorax and abdomen as in the larva, but the chitinization and pigmentation much more advanced; penultimate segment (ninth including the segment mediaire) narrow, somewhat bullate dorsally towards the right; ultimate segment asymmetrically bisected dorsally, each portion produced more or less conically and pointed, in the middle of this armature, between the two titillatores a fleshy process may be exserted. Last ventral segment triangular, simple, but the left side is somewhat excised. The dorsal structure is not visible from below. The left cercus large, single-jointed, clavate, obliquely truncated apically, the right appendage two-jointed, with its outer joint shorter than the inner, both appendages hairy. Wings brown, marked with five secondary veins of wine-red pigment, the second and third connected by two to four cross bands of pigment, the third and fourth sometimes also connected. The central space of the cells is clear hyaline.

In this species the venation of the wings is much reduced, only the base of the subcosta, the radius, the cubitus, and the indefinite base of the anal vein exist as thickened cuticle; the original venation is represented by bands of wine-red pigment arranged like lines of granulations and by series of short hairs. These lines extend just posteriorly to the cuticular thickenings and represent the full venation of the nymph, except that the costa is wanting

in the adult. Owing to this double venation, which, judging from the figures, occurs also in a number of the other species, there has been much confusion in homologizing the veins with those of other insects. On applying the ontogenetic method of Messrs. Comstock and Needham, which fortunately the possession of nymphs of two species enables us to do, it will be seen that the interpretation given by these gentlemen of one of Wood-Mason's figures is nearly correct. It might be suggested, however, that the cross-veins are not to be regarded as branches of

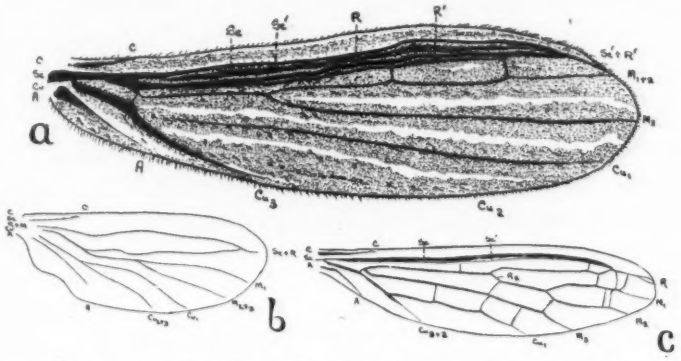

FIG. 2. *a*, wing of adult; *b*, wing of nymph; *c*, wing of *Embia Uhrichi*.

the radius, but as additional veins, for their position is very unstable, and moreover, in the nymph they are indicated merely by a sinuosity on the radius, very much as in *Psocus*,[1] from which type they do not materially disagree. *Texana* has the simplest type of true neuration of any of the species of this family, the veins being reduced to those thickenings mentioned before. Figures of its nymph-wing, which is also identical with that of *mauritanica*, and of the adult wing of *Uhrichi* (copied from Saussure)[2] are given for comparison. In the latter species the neuration reaches its highest degree of complexity.

If before the final moult wing-formation does not take place, the adult stage is attained in a wingless condition. These wingless males are more frequently met with in the nests than the winged form, though never more than one was to be found in a

[1] *Vide, American Naturalist*, XXXII., p. 241, Figs. 11 and 12.

[2] *Mitt. d. Schweiz. entom. Gesell.*, 1896, Pl. Fig. 1.

single nest, which often would contain several females. In color, size and structure both forms of the males are exactly similar. Moreover, they have the same movements, with forelegs elevated, though the wingless male generally carries its abdomen curved further over the back. Their only difference is in the matter of wings.

In the *Entomologists' Monthly Magazine* (1897, p. 56), Mr. R. C. L. Perkins notices a peculiar condition of the thorax of *Embia insularis*. From the hinder angles of the meso- and metathorax project small lobes which he concludes are the beginnings of the wing-pads at the stage immediately preceding the nymph-form. A specimen of a full-grown wingless male of *texana* presents the same peculiarity. This cannot be explained as a case of atavism — an attempt at the wing-formation which this form has lost — for the true wings arise from the anterior angles of these segments and hence are not homologous with these free lobes. Moreover, we have sectioned the fully-grown larva and find the wings as large invaginated pockets completely beneath the hypodermis.

The males of *Solieri* seem undoubtedly all to be wingless, although the evidence rests largely on the absence of winged forms. Professor Grassi and Dr. Sandias obtained numbers of mature wingless males but none with wings. However their observations were interrupted during July to September.

The structure of the anal cerci of the Embiidæ varies with the individual. The males of three species (*tartara*, *texana* and *Wheeleri*) have the left cercus always single-jointed and the right one two-jointed. As far as can be judged from the descriptions all the other species (except possibly *mauritanica*) have both appendages two-jointed in the male as well as in the female. It is among this latter class that the structure of the cercal joints varies.

Herewith is appended a table of all the described species of this family, indicating the extent of polymorphism as far as has been recorded. The localities of distribution are added to accompany the map given later on.

	larva.	nymph. ♂	wingless. ♂	winged. ♂	wingless. ♀	
1. *æthiopicorum* Karsh.				×		N. Camerun, W. Africa.
2. *agilis*[1] Sundeval.	×					Bahia, Brazil.
3. *antiqua* Pictet & Hagen.			×			Prussian amber.
4. *Batesii* McLachlan.				×		Brazil.
5. *bramina* Saussure.				×		Bombay, India.
6. *braziliensis* Gray.				×		Brazil.
7. *cubana* Hagen.	?			×		Cuba.
8. *hova* Saussure.				×	×	Madagascar.
9. *Hubbardi* Hagen.				×		Enterprise, Florida.
10. *humbertiana* Saussure.				×		Ceylon.
11. *insularis* McLachlan.	×	×	×	×	×	Honolula : Antigua Isl.
12. *mauritanica* Lucas.	×	×		×		Algeria.
13. *Michæli* McLachlan.		×	×	×	×	Ambulla, Calcutta, India.
14. *Muelleri* Hagen.					×	Sta. Cattarina, Brazil.
15. *nigra* Hagen.				×	×	Upper Egypt, Cairo Egypt : Kellemisch, Asia Minor.
16. *nobilis* Gerstecker.						Itaituba, Amazon, Brazil.
17. *persica* McLachlan.				×		Shahrud, N. Persia.
18. *ruficapilla* Burmeister.				×		Venezuela : Brazil.
19. *ruficollis* Saussure.				×		Central America.
20. *Salvini* McLachlan.				×		Tehuantepec, Mexico : Chinautta, Central America.
21. *Saundersii* Westwood.			×	×		Bengal, Jubbulpore, Calcutta and Bombay, India : Borneo : Mauritius: Madagascar: Ascension Isl.
22. *Savignyi* Westwood.				×		Egypt : Greece : S. Russia ?
23. *Solieri* Rambur.	×		×		×	Spain : France : Italy.
24. *tartara* Saussure.				×		Turkestan.
25. *texana* Melander.	×	×	×	×	×	Austin, Texas.
26. *trinitatis* Saussure.	×			×	×	Trinidad.
27. *Uhrichi* Saussure.		×		×	×	Trinidad.
28. *Westwoodi* Hagen.				×		Zanzibar ? copal.
29. *Wheeleri* Melander.			×			Cuernavaca, Mexico.

That the wingless males are functional is to be seen from the following interesting observation. On June 1 a male that had been kept in captivity for some time was admitted to the dish containing some isolated virgin females. At once every action denoted an intense excitement. The quivering of the antennæ, the tremors of the body, the hurried runs hither and thither, and the gnawing at the web, were all strangely in contrast with the passive demeanor in the former nest. His entire behavior indicated that his senses perceived the proximity of the other sex. At last a run brought him beside one of the females. A sudden

[1] This species, described as the larva of a new genus of Forficulidæ, *Condylopalama*, will probably never be recognized from the brief description.

calm overcame him, and with his mouth and the fore feet that normally are so inactive, he caressed the head and thorax of his bride. This lulled her to tranquility, and with a sudden dart the male turned around and clasped the eighth ventral in his bifid pygidium. Instantly both were struck with a rigor. They allowed themselves to be turned over without showing a sign of movement, and were it not for the rapid but faint pulsation of the thinner chitin of the segmental interstices of the male they would have seemed as if dead. For four and one half minutes they remained thus, the body of the male twisted over the back of the female, and turned towards her right side. The copulation then being effected they separated, and both ran about with the quiet movements of their ordinary gait. Now we understand why the male so frequently carries the tip of the abdomen uplifted for this position has a functional significance during coition. During this time the heart-beat of the male attains three hundred per minute. This pulsation is remarkable when we remember that the highest number recorded is one hundred and forty-two per minute for *Anthophora*, and that, too, at a time of excitement.

Distribution.

All of the specimens of *texana* were taken in the same situations as were the larvæ described in the June number of this periodical, under flat limestone surface-rocks that form so prominent a feature of this region of the Texas country. Net-sweepings through the grass in the vicinity failed to reveal any specimens. This is to be expected, however, for our species is practically nocturnal. In the case of *mauritanica*, specimens have been taken in grass-sweepings during the daytime, while *nigra* has been found in the same way in the evening. The situations frequented by the different species present quite a range of variation. Some have been found among the roots of orchids where they are said to cause considerable injury (*insularis*, *Michaeli*, etc.). Many construct their web-nests on the fibrous bark of palms and cycads (*Saundersii*, *mauritanica*, *Uhrichi*, etc.). The former species, too have been seen running about on the sand. The habits may vary with the altitude, even. *Insularis* becomes arboreal in high situations but is found under stones in the low-

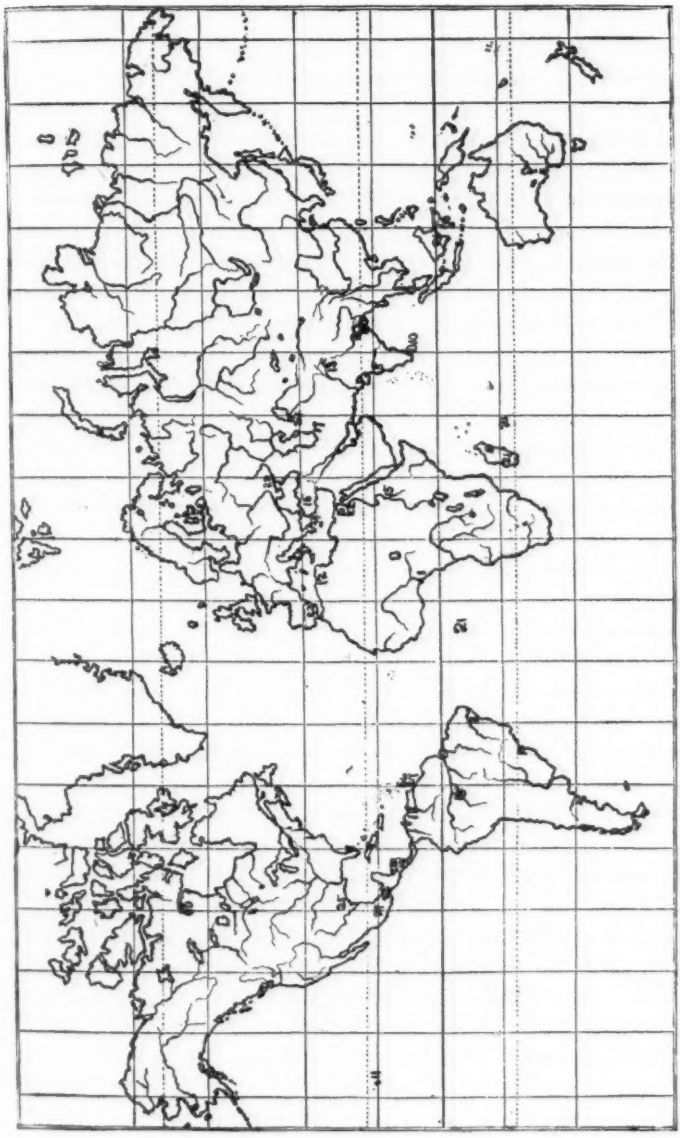

FIG. 3.

lands. During the night the males of this species fly freely to lights. A similar habit has been noticed with the Indian species.

All of the species, however, require a very definite degree of moisture and hence are restricted in their distribution along the seacoast. A glance at the accompanying map will make this evident. Here are plotted the known *patriæ* of the various species, numbering the localities to correspond with the list of species given before. Where the identification is doubtful a cross expresses the provenience. A comparison of the available and recognizable descriptions of previous authors brings to light several facts. The old group *Olyntha* (represented by species 25, 29, 20, 27, 6, 18, 4, 14, and probably by 19 and 26) though untenable as a genus, yet is comprised wholly of American forms. The only other American species, *Hubbardi* and *cubana* are related among themselves and very closely with the Sandwich Island species, *insularis*, which is said to occur in the West Indian island Antigua also. Moreover, *insularis* is a near relative to *Saundersii* (21) which has an extended distribution over Borneo, India, Mauritius, Madagascar and Ascension Island. With this species are grouped also the Indian species, *Michaeli* (13) and *bramina* (5), and possibly also *humbertiana* (10, from Ceylon) and *hova* (8, Madagascar), themselves closely allied and forming small groups. *Mauritanica* (12) and *Savignyi* (22) are stated to be close relatives, and both live along the southern Mediterranean coast. *Nigra* (15) of Egypt is represented by a variety (?) in Asia Minor. Thus we find a number of groups, natural both in structure and in distribution. The New World forms, excepting those of the West Indian fauna, which probably are derived from an oriental source, stand out alone. *Embia Solieri* (23) of southern Europe has little affinity with the other species, its nearest relative being *antiqua* (3) from the Prussian amber, of Tertiary times, a form also with wingless male, and not clearly distinguishable from the living species. India seems to be the point of expression of another group of species (species 13, 5, 21, 10); of these *Saundersii* (21), or forms indistinguishable from it, occurs with a wide island-distribution. It seems to be with these species that *cubana* and *insularis* are to be grouped. Australia, eastern Asia and western South America are, as far as

known, destitute of species. The Embiidæ are therefore seen to be tropicopolitan and also seacoast species, extending only a few hundred miles into the interior along the principal water-courses. In the warmer countries they appear at higher altitudes, in order to preserve conditions of proper temperature and humidity. As the species show a preference for palms and orchids, plants which have a commercial importance, it is not surprising that their distribution is artifically complicated. At least four species have thus been taken in ship-yards and green-houses thousands of miles from their native homes. Moreover, a natural maritime distribution is quite possible on tree-trunks swept down some river during flood-time and then carried about by ocean currents. *Texana* has actually been found under the bark of a fallen tree lying on a flood-plain. The next heavy rain would have carried that tree-trunk down the Colorado River and ultimately to the Gulf of Mexico. These facts should be remembered when we consider the wide distribution of *Saundersii*. It might be mentioned that like so many other introduced animals this species has become exceedingly abundant in some places, even to a source of annoyance in the island of Ascension. *Insularis*, too, is said to be common on the sea-shore, every stone serving to shelter two or three. This fact might indicate an introduction during times not distant, with conditions favorable for a rapid increase in numbers, and only recently an extension into the interior.

That the Embiidæ form an ancient group is undisputed. Their uniformity of structure, so marked that characters of specific importance are few, shows that they have long passed the zenith of their evolution. The variability of the antennæ and of the cerci, and even of the neuration of the wings might suggest a decadence of these organs. The fact that the males are dimorphic and have only partially the need for wings, retaining them possibly only to prevent too close interbreeding, while the females are all wingless, also would lead us to that conclusion. But the Embiidæ have existed a long time in this dimorphic condition of the male, for the wingless form is known in amber from the Tertiary. This family of frail insects, one of the first of the twigs of the great Orthopteran branch, seems certainly in process of extinction, but like other groups which were conservative in special-

ization, they too are destined to outlive many of their later but more plastic companions.

International Anatomy.

The forepart of the alimentary canal consists of a small buccal cavity, a narrow pharynx, dilating into the large œsophageal tract, which extends into the metathorax. The central part of the œsophagus is narrowed, as in *Solieri*. At the hinder end of this portion there is formed by a sudden constriction a narrow tract which terminates that part of the alimentary canal of stomodæal origin. Thus far the tract is lined with a chitinous cuticle presenting differently formed teeth along its course, and is enclosed within a double layer of muscles — the inner layer longitudinal, the outer circular — which become stronger posteriorly. The teeth of the buccal cavity are closely placed, long, directed backward, and attached in sockets. In the pharyngeal constriction they become minute and flattened, more closely aggregated, still directed backward, but appearing like small ctenoid-scale-

Fig. 4. Diagrammatic arrangement of the body-organs in a medial sagittal section. *an*, anus; *malph*, malpighian tubule; *ov*, oviduct; *rect*, rectum; *rect. gl*, rectal gland; *sth*, spermatheca.

like projections of the cuticle. Below the frontal ganglion of the sympathetic system the scales are wanting but recommence further on. The pharynx is thrown into eight strong longitudinal folds, of which two are lateral, two ventral, and four dorsal. This gives to a trans-section of the pharynx a hexagonal, not octagonal, appearance. Within the proventriculus the teeth are reduced to mere granulations of the cuticle, arranged in narrow scattered areas.

The mid-intestine commences as a sudden enlargement more or less telescoping with its pedicel, and which gradually narrows to the point of attachment of the Malpighian tubules in the sixth

segment of the abdomen. Its walls consists of columnar epithelium — short uniform cylindrical cells in the larva and elongate, more or less pear-shaped, irregular, secreting cells in the adult. The muscular layer surrounding the mid-gut is much reduced, and the chitinous lining of the fore-gut is wanting in this portion. At the base of the Malpighian tubules the wall of the mid-intestine is thickened, forming the gastro-ileal valve. Here, in a conical chamber formed just beyond the valve, commences the cuticle from the proctodæal invagination, but unlike the œsophageal chitin, it is thin, replicated and smooth. The ilium is normally much contorted, but when filled with food can be straightened. Its numerous circular muscles then force it tense and crowd the mid-gut into the thorax. The globular rectum fills out the last two segments of the abdomen. When not evacuated it is filled with rasped wood and other fragments of vegetable origin. Its walls are strongly bulged by the six large cushion-like rectal glands which consist of long convoluted secreting (?) cells each with a large central nucleus. The Malpighian tubules vary in number with the age of the individual, becoming about twenty-four in the adult. In the younger stages they are rather shorter and thicker with their nuclei more aggregated, *i. e.*, their cells are smaller. Their cells frequently present a honey-combed structure, probably due to the solution of their contents in the reagents for clearing.

The heart of *Embia* can be distinctly seen through the overlying translucent chitin, extending the length of the body. Even when pigmentation is greatest the heart is still evidently visible from above. The blood corpuscles are large and elliptical.

The supraœsophageal ganglion (brain) of the nervous system is relatively small ; the optic lobes send off a stouter nerve to the eyes than is apparently the case in Professor Grassi's species. This may be in part due to a difference in the power of sight in the two species. The deutocerebrum is flattened, the antennal nerves very slender, an innervation that might be expected for organs of so poor sensory development. Owing to the absence of ocelli there are naturally no ocellar nerves. The subœsophageal ganglion is comparatively large, sending an anterior nerve in front of the œsophageal commissures. The remainder of the

nervous system is nearly similar to that of *Solieri*, consisting of three large thoracic ganglia and seven smaller abdominal ganglia connected by the double ventral cord. The fifth segment is, as has been noticed in *Solieri* and *Uhrichi*, destitute of a ganglion, the ventral cord between the fourth and fifth ganglia being longer than between the others. But in our species the last ganglion (seventh abdominal) is crowded forward, though still remaining larger than the other ganglia of the abdomen. Its position is above the seventh sternite and contiguous with the ganglion in front. In the two species before compared the last ganglion is connected with the sixth by a commissure and is placed in the eighth segment. Each of the ganglia send side branches into the viscera, while the last terminates in a pair of nerves interwoven with the efferent sexual ducts.

The visceral system is somewhat different from that of *Blatta*.

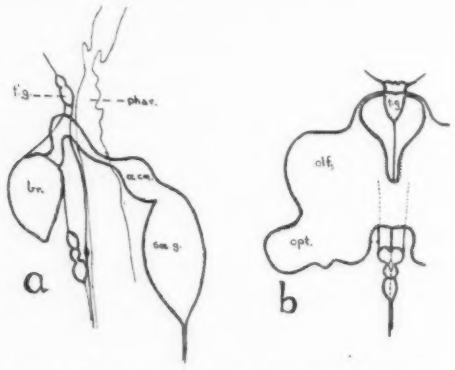

FIG. 5. *a*, lateral; *b*, dorsal view of the cephalic nervous system; *br.*, brain; *f. g.*, frontal ganglion; *œ. cm.*, œsophageal commissure; *olf.*, olfactory lobe; *opt.*, optic lobe; *phar.*, pharynx; *sœ. g.*, subœsophageal ganglion.

It consists of an unpaired triangular frontal ganglion of rather large size, connected laterally by stout commissures with the anterior lobes of the brain. The lower portion of this ganglion ends laterally in nerves extending obliquely forward along the œsophagus. The frontal ganglion ends posteriorly in a long slender nerve lying immediately above the coat of circular muscles of the alimentary tract, and enlarged as two ganglia over the

œsophageal portion, one within the prothorax, the other in the mesothorax, though still lying close over the œsophagus. At intervals this nerve sends off a series of fine nerves anastomosing in minute knots and which terminate within the circular muscles of the tract. The remaining ganglia are unpaired also, lying in the median line above the alimentary tract and within the hind fork of the brain. These are three in number, more or less fused, and the anterior one bilobate. They send but one slender nerve backward, above the one from the frontal ganglion, and are connected with the brain by two commissures arising from the sides of the anterior bilobed ganglion. As the peripheral nerves of this system intimately innervate the muscles of the alimentary tract, conforming with all its irregularities, it would seem that peristalsis is controlled from this source. Professor Blandford did not find the posterior ganglions of the visceral system of *Uhrichi*. This was probably due to their small size in the specimens studied rather than to their complete absence. All the ganglia vary in size almost more than do the other organs of the body. In some cases the posterior ganglia of the visceral system are much reduced and flattened.

The female generative organs agree with the descriptions of those of *Solieri* and *Uhrichi*, consisting of a paired oviduct, each branch of which emits five lateral tubules. In the larval state the tubules are consolidated into a compact elliptical mass, situated dorsally one to each of the five basal segments of the abdomen. Each mass comprises about seven transverse chambers and is connected with the slender oviduct by a short and equally slender strand. In the adult the tubules lengthen by a forward growth, the chambers separate and on becoming elliptical give a moniliform appearance to the tubule. The end-cells remain undifferentiated. In a multiparous female the oviduct becomes greatly distended and its walls much wrinkled. This distension is evident also at the base of the recently emptied follicles. The spermatheca is large, occupying the free portion of the eighth segment. It opens below by a somewhat tortuous duct into the short vagina. The end of the ventral nerve chain passes between the vagina and the spermatheca.

Embryology.

During the few weeks the Embias were kept in captivity the females deposited a small number of eggs. These were laid during the night-time, generally one at a time, and were often insecurely fastened to the surface of the jar by strands of silk. The eggs, a dozen or so in number, were carefully preserved in hope that the history of the embryos would give some clue as to the systematic position of the family.

The eggs are of a creamy-white color and of the retort-shape noticed in *Solieri* and *Uhrichi*, and possess a characteristic narrow circular band of thickened chitin extending obliquely from the apex of the narrower end to one third the distance along one side. This structure is of great service in orienting the egg during the later stages. In the ovaries of the female the eggs lie with the narrowed end anteriorly and the oblique surface directed upward and towards the median line of the body. Thus the primitive ventral surface does not correspond with the definitive, but the anterior end of the ovarian egg remains the anterior end for the hatching embryo. The oblique circle outlined by the ridge is doubtless detached at the time of hatching. The chorion is thin but firm, and presents a smooth finely granular surface. Within the circle, however, the surface is lightly roughened by trabeculæ and minute pillars, its alveolar structure corresponding with the enlarged cells of the follicular epithelium. At the posterior median point of the ridge is a small elliptical opening, the micropyle, communicating with the irregular lumen of the ridge itself. This opening is in connection with a smaller one passing into the interior and provided with a grooved guideway. As in *Blatta*, no gyration of the egg is necessary, during the passage down the oviduct; the micropylar opening comes directly in contact with the mouth of the spermatheca, while the small size of the opening limits the number of spermatozoa that find ingress. The chorion is sometimes thin, due to imperfect secretion, and at times is covered by the shed follicular epithelium. In this detritus and among the strands of silk particles of soil adhere. This might indicate that in the natural nests the eggs are concealed for protective purposes by an added covering. The vitel-

line membrane is comparatively tough and separates from the chorion in eggs kept in an alcoholic preservative.

Unfortunately the youngest embryos were well advanced at the time of preservation, being in an elongate fully-segmented stage. As the embryo now extends over the whole of the definitive dorsal surface with its head directed posteriorly, it probably attained this position by rotation, keeping at the surface of the egg as in the Termites and not plunging through the yolk as in the Orthoptera with elongate eggs. At this stage segmentation is nearly complete, only the posterior end being confused. The antennæ are short, borne by the rather large deutocerebrum which shows a flexure around the posterior pole. The mouth

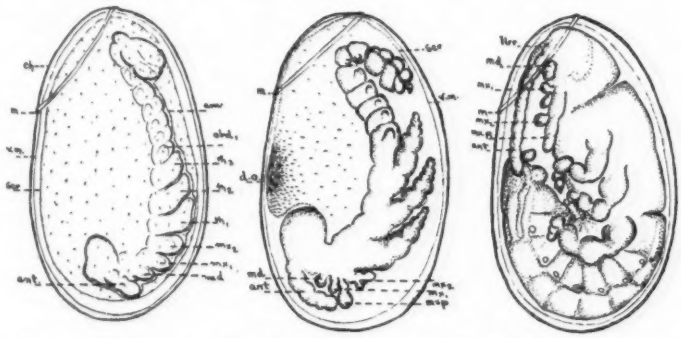

FIG. 6. Three stages of the developing embryo. *am*, amnion; *ant*, antenna; *ch*, chorion; *do*, dorsal organ; *lor*, labrum; *m*, micropile; *md*, mandible; $mx_{1,2}$, maxillæ, *mxp*, palpus; *ser*, serosa, $th_{1,2,3}$, legs; *v. m*, vitelline membrane.

parts are large, single-jointed appendages, the labrum distinctly bipartite. The head segments are nearly as strongly marked as the thoracic. Of the limbs the first pair are slightly more advanced than the others. Whether this is due to the anteroposterior direction of growth or to an acceleration of these important appendages would be hard to decide. The pleuropodia are large, the remaining abdominal appendages are uniformly smaller and disappear on the fifth segment. Beyond this segment the abdomen curves into the yolk, while at the eighth segment there is a sudden outward flexure. The "tail-piece" thus formed is quite like the similar growth of *Termes*, etc. Sections of the

egg reveal only the usual envelopes over the embryo, *i. e.*, the chorion, the tough vitelline membrane, the serosa with large nuclei, the amnion with smaller more rounded nuclei, and the blastodermhaut. The yolk of these eggs, fixed by hot water, shows a definite segmentation, a dozen or so of granules being aggregated about each vitellophag.

During the next few days the embryo changes rapidly in appearance, due to the process of shortening, *i. e.*, broadening. The appendages lengthen, the mouth parts take on their final structure and position, the maxillæ becoming tripartite, much like *Termes*, due to the development of their palpi. The head, however, still continues its accelerated development, but lies free from the yolk. The abdominal legs still persist, though even yet, except for the terminal styles, none are formed on the "tail-piece," which is more flexed than before and in which the proctodæum is seen in process of formation. The serosa and amnion have parted over the embryo and are drawn back as the "dorsal organ."

The last stage of which we have material shows a marked advance in development, although the embryo is but three weeks old. Revolution has now occurred. The envelopes, except the vitelline membrane, as well as the dorsal organ, have disappeared. The embryo has grown over the yolk, but the dorsal abdominal cuticle is still thin and shows its derivation from the serosa by scattered nuclei over its surface. The proctodæum and stomodæum are well formed but still are separated from the yolk-mass. The head-lobes have dwindled to a microcephalic size, the antennæ have lengthened to the base of the fore legs, but even now the maxillary palpi are nearly as long; yet the antennal segmentation is more marked than in the corresponding stage of *Xiphidium;* the labrum is large and separate; the eyes are not yet formed. The tarsi are now suddenly flexed outward, with the front metatarsi distinctly large. The abdomen is stout and much bent on itself. The appendages, except the cerci, have disappeared, and in their stead conspicuous spiracles are developed.

From the rapidity with which these stages are passed through it would seem as though the embryonic life of *Embia* is of short duration. A development at this rate would cause hatching to

occur in late June, at the very height of the dry season. But as these frail insects cannot undergo heat and drought, as has already been shown, it seems not improbable that soon after the last stage described above there is an arrest in development which enables the embryo to æstivate within the protecting chorion until the rains of later summer. Under the conditions of Texas weather it does not seem likely that there are two broods a year. Moreover, from autumn till spring there is a gradual increase in the size of the larvæ observed.

The few stages obtained show nothing but what might be expected in the development of this insect, and simply indicate that the position of the Embiidæ in the superorder Orthoptera is doubtless correct. The latter part of the embryonic history, at least, shows a closer parallelism with the Termitidæ than Grassi's conclusions drawn from the adult structure would lead us to expect. At any rate, the comparatively large size of the head of the young embryo, the persistence of the abdominal legs and the structure of the appendages and of the "tail-piece" might have some phylogenetic bearing. The late formation of the eyes, the enlarged front metatarsi, the relative sizes of the antennæ and maxillary palpi are marks of specialization, indicating arrested or precocious development, and are not to be sought for beyond the ontogeny of this form.

Summary.

The females of the Embiidæ are comparatively large, wingless and symmetrically formed, the males have the abdomen more or less distorted (except species 17, 18 and 22). The males of probably all the species are dimorphic, being wingless (not dealated) or winged. The wings arise from invaginations at a pre-nymphal instar. A nympha-stage with larva-like body is undergone. Venation varies with the species, and generally is-double, represented by true veins and pigment lines. The thickened veins of *texana* are few. Copulation occurs within the nests. The carriage of the male abdomen is attributable to its function. The facets of the Embiid eye are quite like those of a newly-hatched grasshopper.

The entire family is tropicopolitan and prefers the humidity of

the coast-region. Its extended island-distribution appears to be in part artificially effected. Brazil, the Mediterranean region and India seem to be the points of differentiation of the groups *Olyntha*, *Embia* and *Oligotoma*, respectively.

The internal anatomy presents a generalized type. But little change is undergone during metamorphosis. The oviducts of an old female may be as large as the alimentary tract. The females have all available space occupied by the fat body and later by the developing eggs. The brain is much less developed than the ventral nerve chain. The visceral system comprises four prominent unpaired cephalic ganglia.

Embryonic growth is completed in about a month. The eggs have a unique micropylar apparatus and are not oriented in the female in their definitive position. The history of the embryo conforms with the Orthoptera, of which group the family is considered as a conservative and ancient branch.

Hull Zoölogical Laboratory,
The University of Chicago.

A NEW SPECIES OF NEMERTEAN (*Cerebratulus melanops*) FROM THE GULF OF ST. LAWRENCE.

W. R. COE AND B. W. KUNKEL,

YALE UNIVERSITY.

Among a small number of Nemerteans collected by Dr. J. Schmitt at Anticosti was a single perfect individual of a species of *Cerebratulus* which is apparently undescribed. This specimen is of about the size and proportions of medium-sized individuals of *C. marginatus* which probably occurs in the same region, but from which the present species can easily be distinguished by the color and by the possession of several distinct ocelli on each side of the snout. *C. grœnlandicus* Punnett has recently been described from Greenland[1] and may also occur in the same region as the present species, but the absence of ocelli in the former is a sufficient specific distinction. In only a few other species of the genus are ocelli present in the adult worms, although it is possible that they are generally present in very young individuals. Besides the possession of ocelli the species is remarkable because of the presence of a large number of efferent nephridial ducts, although a number of other species, including *C. grœnlandicus*, possess this same peculiarity.

The single specimen on which this diagnosis is based had been preserved in formalin, and may be described as follows: Body elongated, rather slender and ribbon-like, of the general size and proportions of *C. marginatus*. After preservation, rounded in esophageal region, moderately flattened posteriorly, tapering gradually to posterior extremity. Head of moderate proportions as in *C. marginatus;* mouth of large size, elongated, situated as far back as posterior ends of cephalic furrows; proboscis pore small, subterminal; cephalic furrows rather short, separated anteriorly from each other and from proboscis pore.

[1] *Proc. Zool. Soc. London*, p. 99, 1901.

The single preserved specimen measured about 25 cm. in length and 4 to 5 mm. in width.

There are several *ocelli* of moderate size situated in a single row on each lateral margin of the snout. In the single specimen at hand there are three conspicuous ocelli on each side near the tip of the snout (Fig. 1).

FIG. 1. Dorsal view of head, showing position of ocelli and cephalic furrows.

The *color* of the body is olive green on the dorsal surface, with a darker oval area situated on the dorsal side a little behind the tip of the snout; the ventral surface and lateral margins of the body are much paler or colorless.

In internal anatomy the following peculiarities of structure may be noted:

The *epithelium* is composed of the usual slender, ciliated columnar and glandular cells — the latter containing a secretion which stains deeply and is often found extruded in oval masses among the cilia. The two delicate layers of integumental muscles are arranged as in related species. The *cephalic glands* are limited to the anterior portion of the snout. The *cutis glands* form a compact but comparatively thin layer immediately beneath the underlying fibrous layer, as in many related species, and are therefore distinctly separated from the internal longitudinal muscles by the fibrous layer of the *cutis*. The average thickness of the layer of cutis glands is only about one third to one fifth as great as that of the outer longitudinal muscular layer. As in other species, some of the glands show a peculiar affinity for nuclear stains while others take on the plasma stains only, as has been described by Miss Thompson[1] for *Zygeupolia*.

The *proboscis sheath* becomes very small towards the posterior end of the body (Fig. 3) and terminates some little distance anterior to the anus. The *proboscis* is attached anteriorly to the tissues of the head immediately in front of the brain, but whether the posterior end was attached to the wall of the sheath was not determined. From the conditions found in *Cerebratulus lacteus*,

[1] *Proc. Acad. Nat. Sci. Philadelphia*, p. 664, 1901.

Zygeupolia litoralis, and certain other Heteronemerteans, it is not unlikely that the retractor muscle is absent. Only two layers of muscles are present in the proboscis, a longitudinal layer on the outside and a circular layer within — the inner longitudinal layer found in many species of the genus being entirely wanting. Inside the muscles occur the usual nervous plexus and the connective tissue layer situated beneath the inner glandular epithelium.

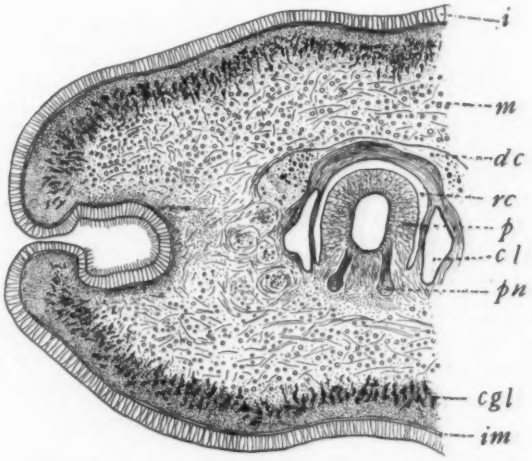

FIG. 2. Portion of transverse section through head in region of dorsal brain commissure (*dc*) and attachment of proboscis (*p*) to tissues of head. The two highly developed proboscis nerves (*pn*) are just on the point of entering proboscis. The disposition of the cutis glands (*cgl*) and their absence beneath the cephalic furrow, the relations of the cephalic blood lacunæ (*cl*) and the cephalic musculature are shown; *i*, integument; *im*, integumental muscles; *rc*, rhynchodæum; *m*, cephalic muscles.

Dorsal and ventral muscular crosses are well developed in this species.

All three of the *muscular layers* of the body walls are well developed. In the posterior portion of the body alone is the internal longitudinal muscular layer very much reduced.

In regard to the alimentary canal it should be remarked that the *esophagus* may be differentiated histologically into an anterior and a posterior chamber, as has been described so fully by Miss Thompson[1] for *Zygeupolia*. The anterior chamber, or esophagus

[1] *L. c.*, p. 706.

proper, is distinguished by a great abundance of ciliated cells with very numerous short cilia and with their nuclei placed near the superficial border of the cells; while the posterior chamber, or *stomach*, is characterized by fewer ciliated cells, and these have less numerous but longer cilia, the nuclei are pressed nearer the basal portion of the cells, and the gland cells contain a much more granular secretion and vacuolated cytoplasm than those in the anterior chamber. The *rectum* is longer than in many related

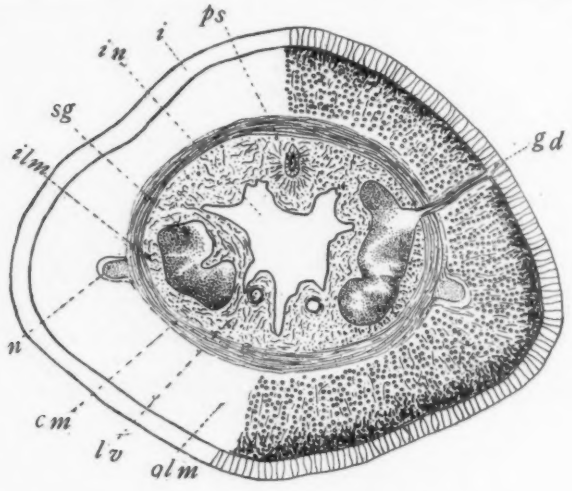

FIG. 3. Transverse section through posterior end of body, showing the very minute proboscis sheath (*ps*), the lateral vessels (*lv*), the sexual glands (*sg*), and the genital duct (*gd*). The internal muscular layer (*ilm*) is here very much reduced while the outer longitudinal muscles (*olm*) remain comparatively massive; *n*, lateral nerve; *in*, intestine; *cm*, circular muscles.

species, and the *anus* opens on the dorsal surface at the posterior end of the body.

The *blood vascular system* presents the usual arrangement of cephalic and esophageal lacunæ. There is a single broad cephalic lacuna (Fig. 4) situated above and beside the rhynchodæum, and extending from near the tip of the snout almost to the brain region where it is divided into two lateral lacunæ by the enlargement of the rhynchodæum (Fig. 4). These two lacunæ unite

ventrally in the brain region to be again separated after a short space. At the posterior end of the brain region they are again united by a broad median lacuna which gives rise to the proboscis sheath vessel posteriorly (Fig. 4). Behind the mouth the lateral lacunæ send off a great many anastomosing blood spaces beside and beneath the esophagus. On the walls of these blood spaces delicate branches of the *nephridial tubules* ramify in all directions. From the pair of nephridial canals which lie on the lateral walls of the lateral blood spaces numerous efferent ducts pass through the muscular layers to the dorso-lateral aspects of the body as usual. These ducts are probably variable in number for in the single specimen sectioned there were thirteen on one side and only seven on the other. In addition to the seven ducts of this side were two incomplete or rudimentary ducts (Fig. 4, *ed*) which did not connect with the

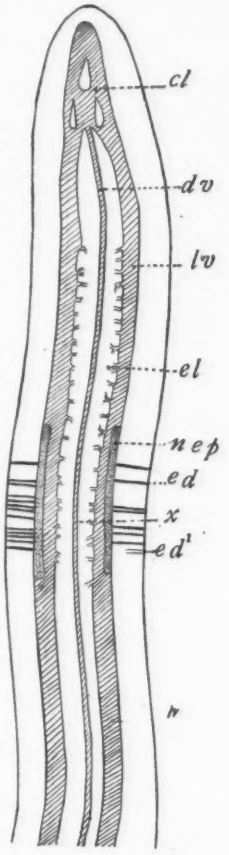

FIG. 4. Diagram of blood vascular system and nephridia. The two cephalic lacunæ (*cl*) unite anteriorly by a rather broad anastomosis. In the brain region are two other anastomoses of the cephalic lacunæ, from the posterior of which the dorsal vessel (*dv*) and the lateral vessels (*lv*) originate. The lateral vessels give rise to profusely branched anastomosing lacunæ (*el*) beside and beneath the esophagus. Dorsal vessel leaves the wall of proboscis sheath in the midst of nephridial region (*x*). The nephridia (*nep*) lie on the lateral walls of lateral vessels about hal way between mouth and intestinal region, and send numerous branches among the esophagal lacunæ. They open to exterior through numerous efferent ducts (*ed*) on each side. In this specimen there were thirteen on one side and seven on the other. There are, however, two rudimentary ducts (*ed'*) on the side with the smaller number.

nephridial canals at all and are apparently the remains of formerly functional ducts which, for some reason or other, have become degenerated and no longer functional. Similar rudimentary efferent ducts have been noticed in several other forms.

The *brain and the esophageal, dorso-median* and *lateral nerves* are as in related species. The *proboscis nerves* of which there is a single pair arising from the ventral ganglia, near the origin of the ventral commissure, are remarkably large and conspicuous. As seen in Fig. 2, they enter directly into the ventral wall of the proboscis at its attachment to the tissues of the head (immediately in the region of the dorsal brain commissure) and then pass into the midst of the longitudinal muscles of the proboscis where they divide into a number of smaller nerves. A short distance behind the brain these spread out into a plexus beneath the epithelium, as in other species in which the inner muscular layer of the proboscis is wanting. The three slight pits on the tip of the snout, representing the *frontal sense organs*, are comparatively well developed. *Cerebral sense organs* are also highly developed, and exhibit the usual structure and relations with the dorsal ganglia and the cephalic furrows.

The *sexual glands*, which alternate with the diverticula of the intestine, become mature in midsummer. The *genital ducts*, when fully formed, open through the muscular layers to the dorso-lateral aspects of the body as in related species.

NOTES ON THE REARING OF THE LARVÆ OF POLYGORDIUS APPENDICULATUS AND ON THE OCCURRENCE OF THE ADULT ON THE ATLANTIC COAST OF AMERICA.

R. P. COWLES,
JOHNS HOPKINS UNIVERSITY, BALTIMORE, MD.

As the larvæ of *Polygordius* are often found in abundance at Wood's Hole, Newport, Beaufort, and along the coast of Virginia, it seems strange that the adult *Polygordius*, which has been found so often in Europe and which has been so well monographed by Fraipont, should not be taken on the coast of America.

The larvæ of *Polygordius* were quite abundant at Beaufort, N. C., during August of 1902, and through the kindness of the United States Fish Commission, I was able to collect some of these and watch their development in the Commission's new laboratory. It surprised me to find that fully developed swimming larvæ taken at night and measuring slightly less than 1 mm. in length had metamorphosed by the next morning. They were at this time 2 mm. in length, showing an increase of 1 mm. in length.

Fraipont in his monograph on *Polygordius* says that the trunk in *Polygordius appendiculatus* develops inside of the primary cuticle of the swimming larva, becoming folded more and more and that it becomes quite long before it assumes the form which is found in the later stages of development of other species. Examination of the larva which is found at Beaufort shows that this is the case.

In Fig. 1 is shown the swimming larva some time before metamorphosis. The trunk has begun to be folded and the primary cuticle is still seen unbroken along its side. As this larva develops, the trunk becomes folded more and more. This folding of the trunk and the exceptional increase in the length of the latter before the primary cuticle breaks, affords an explanation of

the seemingly rapid metamorphosis of the larva into the adult form and also it shows why the young worm immediately after metamorphosis is so much longer than the fully developed larva.

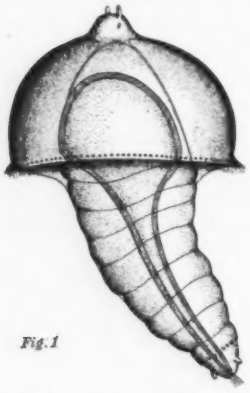

FIG. 1. Larva of *P. appendiculatus*, ×68.

The anal segment is of specific interest in the larva (Fig. 1) which is found at Beaufort, N. C., because it bears the beginnings of two anal filaments which are characteristic of the larva of *Polygordius appendiculatus*. Besides these organs there is on the anal segment a tuft of cilia about the anus. Anterior to the anal filaments there is a ring of glandular papillæ. A pre-anal ring of cilia was not observed.

At the suggestion of Dr. Grave, of the Johns Hopkins University, the young worms, after the completion of metamorphosis, were put into dishes with water and sand rich in diatoms. In order to obtain sufficiently rich cultures of diatoms to afford enough food for the worms, sand was obtained by means of a dredge outside of the harbor and put into aquaria jars with fresh sea water. The jars were then kept in the laboratory near a window until the sand had settled and a rich culture of diatoms had appeared as a brown layer on the top of the sand. This was then drawn off with a pipette and fed to the young worms. Under these conditions they grew rapidly and at the end of six weeks some of them had increased in length to 15 mm. Examination of the contents of the alimentary canal showed that the worms had been feeding on the diatoms.

This method of rearing the young metamorphosed larvæ was first employed by Grave to rear young Echinoderms. By this method also the writer has had good success in rearing the larvæ of *Thalassema* taken from the tow at Beaufort, N. C., and he has half-grown specimens of *Thalassema* which are living and growing under these conditions in the laboratory of Johns Hopkins University.

There is no doubt but what the diatom method is a most useful one in rearing well-developed larvæ taken from the tow.

In Fig. 2 is shown the anal segment of a *Polygordius*, 15 mm. in length, raised by the diatom method. The characteristic anal

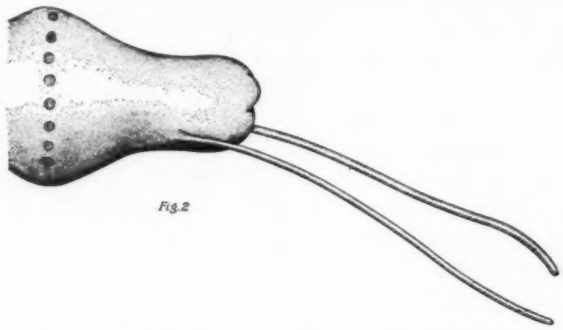

FIG. 2. Anal segment of a specimen of *P. appendiculatus*, × 135.

filaments in this specimen are almost three times the length of the anal segment, as in *P. appendiculatus* as figured and described by Fraipont.

Sections of the anal filaments show that they are ectoderma. outgrowths surrounded by a cuticle which is continuous with that of the rest of the worm. They are without lumens and the cells seem to be like those of the ectoderm of other parts of the body of the worm. It is possible that the organs have a sensory function, although they are not at all active and are not ciliated. The ring of glandular papillæ present in the larva persists in the adult. In the oldest specimen that the writer has, the superior anal lip is not as distinctly divided into lobes as Fraipont figures, but there is some indication of differentiation into lobes.

FIG. 3. Cephalic segment of the same specimen as that of Fig. 2, × 135.

The cephalic tentacles (Fig. 3) are seen to be without setæ and longer than in other species, as is the case in *P. appendiculatus*

Sections show that there is no circular muscle layer below the epidermis and also that there is no muscular layer enveloping the alimentary canal. Fraipont observed these facts also.

Although the worms reared by the diatom method had not reached sexual maturity, there can be no doubt but what the form is *P. appendiculatus*, since the two characteristics which distinguish this species from all others are present, namely:

The advanced stage of the development of the trunk before the primary cuticle of the larva is broken and the presence of the two filaments on the anal segment.

There is another *Polygordius* larva which has been taken in the tow at Beaufort, N. C., but its metamorphosis is different from that of *P. appendiculatus* and the anal filaments are not present. Although the writer has not attempted to rear the larva, its metamorphosis and anatomy resemble that of *P. neapolitanus*.

The *Polygordii*, raised by the diatom method, were found to be very active little worms. By means of the glandular papillæ on the anal segments, they were usually found attached to the bottom of the dish, but the rest of the body anterior to this was kept in almost continual motion, waving back and forth and often tying itself into knots.

It is not strange if *Polygordius* has not been found on this coast. In addition to the fact that they are small, thread-like worms living free in the sand, they have the habit of coiling themselves into a minute snake-like coil when disturbed. If they are not more abundant than the most abundant annelids at Beaufort, it would only be by the most painstaking search that they would be found.

ON THE EFFECT OF VARIATIONS IN THE TEMPERATURE UPON THE PROCESS OF ARTIFICIAL PARTHENOGENESIS.

ARTHUR W. GREELEY.

In a previous paper[1] it has been shown that the unfertilized eggs of *Asterias* may be made to develop parthenogenetically by exposing them for a definite length of time to a temperature of 1° C. to 7°C. These experiments were the outcome of others[2] in which it had been demonstrated that the cells of *Spirogyra* and some Protozoa may be made to lose water by lowering the temperature. From these observations on the effect of low temperature on simple animal and plant cells, it is made probable that the artificial development of the *Asterias* egg by means of a lowering of the temperature is brought about by an extraction of water from the protoplasm, just as if the eggs had been placed in a solution of a higher osmotic pressure than that of the sea-water. This latter method has been found to be successful for the *Asterias* as well as the *Arbacia* egg by Dr. C. H. Neilson. Beyond the fact that a low temperature brings about certain changes in the physical condition of the protoplasm that result in a loss of water, nothing is known concerning the action of low temperatures upon the egg.

In the course of experiments on artificial parthenogenesis it has been noted by several observers that the experiment must be performed within certain very narrow limits of temperature. Above or below these limits of temperature, of which 20° C. may be taken as the mean, the experiments have failed with any of the methods heretofore used to obtain artificial parthenogenesis. In order to determine, if possible, the rôle which temperature plays in this process, Dr. Loeb suggested that I repeat some of the well-known experiments in artificial parthenogenesis, test-

[1] Greeley, *American Journal of Physiology*, VI., 1902, p. 296.
[2] Greeley, *ibid.*, VI., 1901, p. 122.

ing the effect of the solution upon the egg at different temperatures.

All the salt solutions used in the experiments on artificial parthenogenesis may be divided into two classes according to their supposed action upon the protoplasm: first, those solutions used at a higher concentration than that of sea-water which produce parthenogenesis through the extraction of water from the protoplasm; and, second, those solutions used at the same or at a less concentration than that of the sea-water which affect the egg through the specific action of ions. In the light of the observations already made on the effect of changes in temperature upon protoplasm, it was a point of considerable interest to determine whether variations in the temperature would affect the action of each of these classes of solutions upon the egg in the same way. Since the speed of a chemical combination varies directly with the temperature, it might be supposed that the specific action of an ion upon the egg would be inhibited or slowed by lowering the temperature, and accelerated by raising the temperature, up to the point where the protoplasm begins to go into heat-rigor. And similarly, since a reduction of the temperature extracts water from the protoplasm, the action of concentrated solutions upon the egg ought to be increased by a lowering of the temperature. Such a disparity between the effect of variations in the temperature upon the chemical and osmotic methods of producing artificial parthenogenesis was, however, not found to hold. A lowering of the temperature, for example, inhibits or slows the action of all solutions upon the egg, whether they are isotonic or hypertonic to sea-water.

The experiments were performed at Woods Hole, during the summer of 1902, with such temperatures as could readily be obtained in the laboratory with the aid of an ordinary hot-air oven and a refrigerator. Four temperatures were used; namely, 30° C., 23° C., 11° C. and 2° C. The solutions to be used in the experiments were prepared and divided among four dishes. The dishes were placed at these four temperatures, and allowed to stand forty-five minutes before the addition of the eggs. The eggs were then distributed among the various dishes at the different temperatures, and after certain intervals of time, were re-

moved to fresh sea-water at the temperature of the room. After removal to the room temperature the eggs were carefully examined from time to time to determine the exact proportion of segmentations and swimming larvæ produced by the same solution at the four temperatures mentioned above. Great care was taken that, with the exception of temperature, all the conditions affecting each lot of eggs might be identical.

The following eggs and methods were used: *Arbacia* eggs, action of concentrated solutions of $MgCl_2$, NaCl, and of sea-water concentrated by evaporation; *Asterias* eggs, action of acids and a concentrated solution of KCl; *Amphitrite* eggs, action of $Ca(NO_3)_2$. Each solution was tried at the four temperatures mentioned above. All these solutions, with the exception of the acids and the $Ca(NO_3)_2$, are of a higher osmotic pressure than the sea-water, and affect the eggs through the extraction of water. In the case of the acids and $Ca(NO_3)_2$, the osmotic pressure remains unchanged, and the fertilization is ascribed to the specific action of the H or Ca ion.

We will consider first the effect of variations of temperature on the process of artificial parthenogenesis when produced by those solutions which extract water from the egg.

Experiment 1.—*Arbacia* eggs were placed in the following solution: 50 c.c. $2\frac{1}{2}n$ $MgCl_2$ plus 50 c.c. sea-water, and were removed to normal sea-water at intervals of 1, 2, $3\frac{1}{2}$ and 5 hours. The following temperatures were used: 30°, 23°, 11°, 2° C. Only a small proportion of swimming blastulæ were formed at a temperature of 23° C. and about half as many at 11° C. No development took place at 30° C. or 2° C. This was not a successful experiment, as only a small percentage of eggs segmented at all. An increase and a decrease in temperature, to 30° C. and 2° C. served equally well to entirely inhibit segmentation.

Experiment 2.—*Arbacia* eggs were placed in the following solution: 11 c.c. $2\frac{1}{2}n$ NaCl plus 89 c.c. sea-water. Same temperatures and periods of exposure to the solution as in experiment 1. The results of this experiment will be given in tabulated form as follows:

PERIODS OF EXPOSURE TO SOLUTION.

	1 hour.	2 hours.	3½ hours.	5 hours.
30°	0	0	0	0
23°	5	10	0	0
11°	0	5	15	20
2°	0	·5	·5	10

The figures indicate the number of swimming blastulæ formed in 100 eggs. At a temperature of 30° C. no development took place as a result of the NaCl solution, except a few irregular segmentations. At 11° C. a slightly longer residence in the solution over that necessary at the room temperature (23° C.) was required, although at periods of three to five hours a larger percentage of blastulæ were formed than at the room temperature. At a temperature of 2° C. a still longer exposure to the solution was required to produce any effect. At this temperature practically no development took place until the eggs were exposed to the solution for five hours. At 30° C. only a few irregular segmentations occurred as a result of the NaCl solution.

Experiment 3. — *Arbacia* eggs were placed in the following solution: 100 c.c. sea-water concentrated by evaporation to three fourths its volume. This solution has the same relative proportion of ions as normal sea-water, and hence its only effect upon the egg can be the purely physical one of extracting water from it. The same temperature and periods of exposure were used as in experiments 1 and 2. The results will be presented in tabulated form as in experiment 2.

PERIODS OF EXPOSURE TO SOLUTION.

	1 hour.	2 hours.	3½ hours.	5 hours.
30°	0	0	0	0
23°	0	4	·5	0
11°	0	15	25	20
2°	0	·5	·4	3

Many more of these eggs segmented at the room temperature (23° C.) than is indicated in the table, but the cells fell apart before complete blastulæ were formed. Practically the same general result is seen as in experiment 2. The optimum period of exposure to the concentrated sea-water becomes increasingly longer as you lower the temperature, but with these longer

periods of exposure and low temperatures, a larger percentage of blastulæ are formed than at the temperature of the room. An increase in temperature to 30° C., as in experiment 2, entirely inhibited the development of the egg.

Experiment 4.—*Asterias* eggs were placed in the following solution: 15 c.c. 2½*n* KCl plus 85 c.c. sea-water. This method was suggested to me by Dr. C. H. Neilson. Same temperatures were used as in the previous experiments. The eggs were removed from the solution after the following periods: 5 min., 15 min., 30 min., 45 min., 1 hour and 2 hours. The results are tabulated as follows:

PERIODS OF EXPOSURE TO SOLUTION.

	5 min.	15 min.	30 min.	45 min.	1 hour.	2 hours.
30°	1	1	0	0	0	0
23°	20	30	5	0	0	0
11°	0	5	25	20	3	1
2°	0	0	0	.2	1	10

This experiment shows very clearly the inhibiting action of low temperatures on the process of artificial parthenogenesis at short periods of exposure to the solution. The period of exposure necessary to produce development increases steadily as the temperature is lowered, although the optimum period of exposure at any temperature varies greatly according to the maturity of the eggs. The development produced at a temperature of 2° C. after two hours' exposure, was shown not to be due to the low temperature alone by control experiments in which eggs in normal sea-water were kept at this temperature. No development by means of low temperature alone can be obtained, unless the eggs are exposed to the low temperature from three to five hours. At 30° C. again practically no development occurred.

We now turn to the effect of variations in the temperature on the process of artificial parthenogenesis when produced by the action of specific ions.

Experiment 5.—*Asterias* eggs were placed in the following solution: 5 c.c. *n*/10 HCl plus 100 c.c. sea-water. This is a method[1] which has been elaborated by Loeb and Neilson and with favorable lots of eggs yields a very high percentage of de-

[1] Loeb, Fischer and Neilson, *Archiv für die ges. Psychologie*, 1901.

velopment. The same temperatures and periods of exposure were used as in experiment 4. The results are tabulated as follows:

PERIODS OF EXPOSURE TO SOLUTION.

	5 min.	15 min.	30 min.	45 min.	1 hour.	2 hours.
30°	2	0	0	0	0	0
23°	30	20	1	0	0	0
11°	0	75	75	50	25	0
2°	0	4	15	20	30	2

Practically the same result was obtained as with the KCl solution. The low temperature slows the action of each solution about equally, although the KCl solution extracted water from the egg and the acid solution affects the egg only through the specific action of the H ion. As in the previous experiments, an even larger percentage of larvæ was produced with a low temperature and long exposure, than at the temperature of the room. A temperature of 30° C. had the same inhibiting effect as in the preceding experiments.

Several experiments were performed on the effects of different temperatures upon the process of artificial parthenogenesis in the *Amphitrite* egg when produced by the specific action of the Ca ion. The following solution was used: 4 c.c. *n* $Ca(NO_3)_2$ plus 96 c.c. sea-water. Results were obtained in general similar to those already described for *Arbacia* and *Asterias*, although they were not nearly so uniform. Artificial parthenogenesis occurs at all the four temperatures tried with periods of exposure as short as fifteen minutes, but the optimum period of exposure is much longer at the low temperatures than at the temperature of the room.

In a previous paper[1] I described some experiments on the effects of an increase in temperature alone upon the unfertilized *Asterias* eggs. In no case did I get even a segmentation of the egg by an increase in temperature. These experiments were repeated this summer upon the eggs of *Amphitrite* and *Asterias* with the same result. I modified the experiment in many ways, keeping some of the eggs constantly at a slightly higher temperature than that of the room, while others were returned to normal sea-water after varying periods of exposure to temperatures ranging from 27° C. to 35° C. The protoplasm of the *Asterias* egg

[1] Greeley, *American Journal of Physiology*, VI., 1902, p. 296.

exists in a very delicate condition of equilibrium as regards its relation to the surrounding temperature. An increase in temperature of only 3° C. over that of the room (24° C. to 27° C.) suffices to liquefy the protoplasm of the egg. Within two hours after the eggs have been exposed to this increase in temperature, the protoplasm loses its granular appearance, becomes clear and homogeneous and flows out, greatly extending the egg membrane. At the same time or before the process of liquefaction has become complete, the nuclear wall breaks down or goes into solution, and the eggs in this stage appear to contain from two to thirty or more nuclear fragments scattered throughout the cell. After six to eight hours' exposure to this increase in temperature, the protoplasm goes into heat-rigor, but beyond the fragmentation of the nucleus, in no case was there even a semblance of segmentation.

This exceedingly delicate condition of equilibrium as regards the physical condition of the protoplasm of the unfertilized *Asterias* egg and its relation to the surrounding temperature, makes it so sensitive to any increase in the temperature, that is seems well-nigh impossible to cause the segmentation of the egg by that means.[1] The subject is by no means closed, however, and further experiments will be performed along this line.

This profound change in the physical condition of the protoplasm as a result of a very slight increase of temperature may explain the fact noted in all the descriptions of the experiments in this paper, that at a temperature of 30° C., artificial parthenogenesis cannot be produced with any of the methods heretofore used. Even at a temperature of 27° C. the protoplasm of the *Asterias* egg becomes completely liquefied, and in this condition no segmentation of the egg can occur.

Summary.

1. The length of exposure to a solution necessary to produce artificial parthenogenesis of the unfertilized eggs of *Asterias* and *Arbacia* varies inversely with the temperature. This applies to

[1] In a recent paper, however, Delage (*Archives de Zoöl. Exper.*, 1902) describes experiments in which he obtained artificial parthenogenesis of the *Asterias* egg by raising the temperature.

all the solutions used, whether they exert a chemical or an osmotic effect upon the egg. But, at the same time, with lower temperatures and longer periods of exposure to the solution, a larger percentage of larvæ are formed than at the temperature of the room.

2. An increase of temperature to 27° C. liquefies the protoplasm of the *Asterias* egg, and produces a fragmentation of the nucleus. At 30° C. it was found impossible to produce artificial parthenogenesis in *Asterias* or *Arbacia* with any of the solutions used.

EREBOMYRMA, A NEW GENUS OF HYPOGÆIC ANTS FROM TEXAS.[1]

WILLIAM MORTON WHEELER.

The occurrence of a new genus of ants in a country so long known to entomologists as the United States is a matter of surprise when we reflect that the Formicidæ constitute a much smaller family and one much better understood taxonomically than many of those that go to make up the great order of the Hymenoptera, and that, notwithstanding the zeal of collectors, new ant genera are rarely brought to light at the present time even in the most remote and inaccessible regions of the globe.

Early in October Mr. W. H. Long, Jr., kindly sent me from Denton, near the northern boundary of Texas, a number of ants, which, had only the minute yellow workers been present, I should have regarded at first sight as specimens of our common *Solenopsis molesta* Say. But the large males and still larger females in the same vial were so unlike any ants I had ever seen that I undertook a more careful examination of the workers and found them to differ not only from any of the known American genera but also from the Old World genera as well.

In response to a request for data concerning the capture of the specimens, Mr. Long sent me the following: "I have seen this species only once. That was early one morning (I believe it was September 21) after a warm rain the night before. My attention was attracted by an old hen greedily devouring the winged forms as they issued from a small hole in a clear, open space in my back yard. There were no rocks, heaps of earth or surface indications of a nest of any kind. Most of the males and females flew away at once, but here and there I saw a few couples mating near the nest. The diminutive workers fondled and clung to the sexual individuals till the latter escaped into the air. There were many more males than females."

The following is a description of the new genus and species which I take pleasure in dedicating to Mr. Long, as a very slight

[1] Contributions from the Zoölogical Laboratory of the University of Texas, No. 45.

acknowledgment of his aid in working out the distribution of our Texan Formicidæ.

EREBOMYRMA gen. nov.[1]

Worker.—Diminutive and monomorphic. Integument yellow, almost without pigment.

Head rather large, suboblong, its posterior border nearly straight, its lateral borders slightly convex. Mandibles rather long, with oblique, 4-toothed blades. Clypeus short, with concave median surface and a pair of teeth on its anterior border. These project downwards rather than forwards and are continued upwards as two distinct ridges on the clypeus. Eyes about one third the length of the head from the insertion of the mandibles, very small, consisting of a single indistinct lens and a few granules of pigment. Ocelli absent. Frontal carinæ short, somewhat further apart than in *Solenopsis*, forming on either side a small lappet covering the insertion of the antenna and then suddenly diverging posteriorly and ending abruptly. Frontal area small, triangular, indistinct. Frontal groove obsolete. Antennal foveæ well-developed. Antennæ 11-jointed; scape of the usual form, first to eighth joint of funiculus together hardly as long as the distinctly 2-jointed club; first funicular joint as long as the four succeeding joints taken together and distinctly broader; joints 2–7 broader than long; eighth joint about as long as broad; basal joint of club about two fifths as long as the terminal joint. Labial palpi 2-jointed, maxillary palpi 1-jointed. Thorax considerably narrower than the head, prothorax with rounded humeri, somewhat flattened above and not separated by a distinct suture from the mesothorax; meso- and metathorax of nearly the same width and distinctly narrower than the prothorax; meso- and epinotum separated by a deep constriction, epinotum armed on either side with a flattened tooth which is hardly longer than broad at its base and continued downwards and backwards as a distinct lamella; dorsal and declivous surfaces of epinotum of about equal length. Petiole in profile much larger than the postpetiole; with a high, rounded node and a slender median tooth on its anterior ventral surface. Seen from above the petiole is more than twice as long as broad, widest behind the middle, slender and subpedunculate in front. Postpetiole seen from above broader behind than in front, campanulate, its posterior edge about twice as broad as the petiole; in profile its dorsal and ventral surfaces are moderately convex. Gaster rather small, narrower than the head, elongate elliptical and somewhat flattened dorsoventrally; anal opening distinctly on the ventral surface, in front of the apex of the gaster. Sting small and apparently vestigial. Legs robust, the femora and tibiæ incrassated, the former towards

[1] From Ἔρεβος, Erebos and μύρμος, ant; an allusion to the subterranean habits and the gloomy coloring of the males and females.

the middle, the latter towards their distal ends. Middle and hind tibiæ without spurs. Claws simple.

Female.—Very large as compared with the worker; deeply colored.

Head subquadrate, convex above; posterior border slightly concave, sides nearly parallel, posterior angles rounded. Eyes and ocelli rather small, the former round and placed in front of the middle of the head; median ocellus depressed. Mandibles convex, with oblique 6-toothed blades. clypeus short and broad, somewhat flattened in the middle, the teeth and their longitudinal ridges on the anterior border obsolescent. Frontal carinæ short, rather evenly diverging posteriorly, in front forming a slight fold over the antennal insertion. Frontal area triangular, longer than wide, continued back as a rather deep frontal groove as far as the anterior ocellus, just in front of which it becomes somewhat broader. Antennæ 11-jointed; scape very short, not reaching the posterior orbit, distinctly incrassated. Funiculus short and compact, with an indistinctly 3-jointed club, the penultimate joint of which is more than half as long as the terminal joint, the antepenultimate nearly half as long as the penultimate and but little thicker than the basal joints of the funiculus. Thorax of the usual structure; epinotum with a blunt tooth on either side continued downwards to the posterior edge as a low, rounded ridge. Petiole seen from above not broader than long, its base very shortly pedunculate; anterior declivity long and very convex, at the summit passing abruptly into the very concave posterior declivity, so that the summit of the node forms a trenchant transverse ridge; lateral surface on either side longitudinally carinate, ventral surface somewhat compressed and produced anteriorly into an acute median tooth like that of the worker. Postpetiole in profile but little smaller than the petiole, and when seen from above but little broader; its anterior border straight, its anterior angles rounded, its posterior border semicircular and fitting back into a deep semicircular excision of the first gastric segment; sides of the postpetiole carinate. Gaster large, fully two and one half times as long as broad and but little broader that high. Anal opening and sting inconspicuous, decidedly ventral in position. Legs rather short and weak, the terminal joints of the tarsi more tapering than in the worker. Wings of the usual form, long and well developed. Venation much like that of *Solenopsis*, with well-developed radial, cubital and discoidal cell; the last larger than in *Solenopsis* and its opposite sides much more nearly parallel; external branch of cubital vein turning forwards and meeting the costa some distance in front of the tip of the wing; median vein and internal branch of cubital reaching very nearly to the margin of the wing; posterior cross-vein short and perpendicular to the median and internal veins. Pterostigma well developed.

Male.—Much larger than the worker but smaller than the female, deeply colored.

Head in proportion to the thorax much larger than in *Solenopsis;* excluding the eyes distinctly broader than long, rounded behind. Eyes and

ocelli very large and prominent. Cheeks much longer than in *Solenopsis*. Mandibles well developed, overlapping, with very oblique 4-toothed blades. Clypeus about as long as broad, very conspicuously convex, hemispherical, its anterior border somewhat truncated, without teeth. There is a small, round, deep pit on either side near the base of the clypeus. Frontal groove and carinæ hardly developed. Antennæ rather short, 13-jointed, of nearly uniform thickness throughout except for the scape and second joint, the former being somewhat thicker, the latter somewhat narrower than the other joints; scape and joints 3–13 cylindrical, more than twice as long as broad; second joint about half as long as any of the succeeding joints, of the usual shape and not globose as in *Solenopsis*. Thorax large, with unarmed epinotum or in some specimens with only blunt protuberances in the place of the worker armature. Petiole hardly pedunculate, in profile a little longer than high, its lower surface without a tooth, its node moderate, with the anterior declivity longer and more uniformly sloping than the posterior. Postpetiole shorter than the petiole but twice as broad, campanulate, broadly open behind and conspicuously overlapping the first gastric segment especially on the dorsal side. Gaster elongate-elliptical, rather pointed posteriorly, distinctly compressed dorsoventrally. Genitalia more or less, in some specimens considerably, exserted. Legs rather long and slender. Wings like those of the female.

EREBOMYRMA LONGII sp. nov.

Worker.—(Figs. 1 and 2.) Length 1.5–2.25 mm.

Varying from amber yellow throughout to pale brown; only the teeth and edges of the mandibles dark brown or black.

Mandibles shining, somewhat striated, with coarse piligerous punctures. Clypeus in the middle between the longitudinal ridges smooth and shining, sides more opaque and rugose. Anterior angles of head and outer portions of antennal foveæ subopaque, traversed by regular and parallel longitudinal rugæ. Frontal area and upper surface of head smooth and shining, covered with rather coarse piligerous punctures. There are a few longitudinal rugæ extending back from the frontal carinæ half way to the posterior border of the head. Sides and ventral surface of head opaque, reticulate-rugose. Antennal scape reaching half way to the posterior angle of the head, slender at the base and somewhat thickened towards the apex. Pro- and mesonotum smooth and shining, with indistinct piligerous punctures. Mesopleuræ and epinotum coarsely and evenly reticulate-rugose, even to the tips of the teeth and the space included between them. Petiole similarly, but somewhat less coarsely, reticulate-rugose, except on the upper surface of the node which is smooth and shining. Postpetiole, gaster, legs and antennæ smooth and shining.

Whole body covered with rather long and abundant pale yellow hairs which on the mandibles, head and thorax arise from the punctures. These hairs are longest on the clypeus and posterior segments of the gaster.

They are conspicuous on the legs and antennæ, especially on the scape and all the joints of the funiculus except the club. On the upper surface

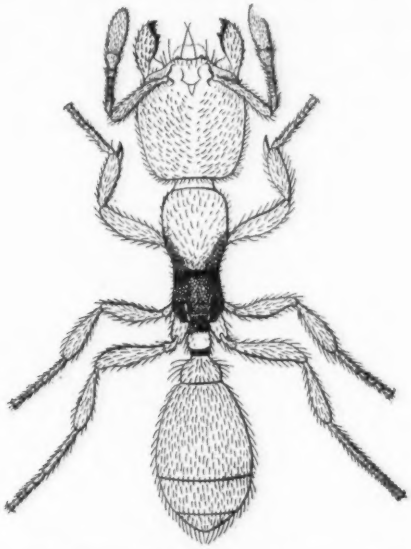

FIG. 1. *Erebomyrma Longii* sp. nov. *Worker.* (Dorsal view.)

of the head the hairs are somewhat more appressed and directed from either side towards the median line which is rather bare. There is no pubescence.

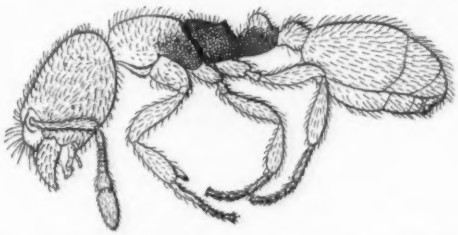

FIG. 2, *Erebomyrma Longii* sp. nov. *Worker.* (Lateral view.)

Female.—(Figs. 3 and 4.) Length 8–8.5 mm.

Black; abdomen, antennæ and legs blood-red; wing insertions, metanotum, lower portions of epinotum, petiole, and postpetiole, the frontal carinæ and lateral portions of clypeus suffused with red; mandibles black, with a broad red band across their apical third; bases of coxæ and middle

portions of femora black; wings black, except their apical third which is hyaline; nervures and stigma black.

Mandibles very smooth and shining, covered with coarse piligerous punctures irregularly interspersed with much smaller punctures. Middle portion of clypeus smooth and shining, finely and irregularly punctate; outer portions grossly punctate except laterally where they are very coarsely longitudinally rugose. Frontal area subopaque. Head opaque, very coarsely and evenly longitudinally rugose, the spaces between the rugæ

FIG. 3. *a. Erebomyrma Longii* sp. nov. Female. *b.* Worker drawn under the same magnification.

being faintly and confluently foveolate. In the antennal foveæ the rugæ are beautifully concentric, on the front and sides of the head they are longitudinal, but in the region of the ocelli diverge and separate into two systems, passing to the posterior angles of the head. On the occiput the space between the diverging series is filled by a transverse series of rugæ. Antennal scape rugose and very coarsely punctate, or foveolate. Thorax largely opaque, pronotum and neck more densely reticulate and longitudi-

nally rugose than the head ; mesonotum subopaque, with a smooth, shining band down the middle and along each parapsidal furrow ; with the exception of these regions the whole surface is covered with large elongate-elliptical foveolæ, the spaces between which are more finely punctate and raised into indistinct longitudinal rugæ. Paraptera and scutellum shining, with transversely elliptical foveolæ which are almost absent in the middle of the latter sclerite. Mesopleuræ shining and foveolate like the mesonotum. Surface of metanotum irregularly foveolate and in addition covered with fine, more or less longitudinal rugæ. Epinotum very opaque, densely punctate above and longitudinally rugose below. In the region between the teeth and the ridges running backwards and downwards from them, the surface is crossed by rather coarse transverse rugæ. Convex dorsal surface of petiole very smooth and shining, finely and sparsely punctate and with a few round foveolæ which are most numerous along the posterior

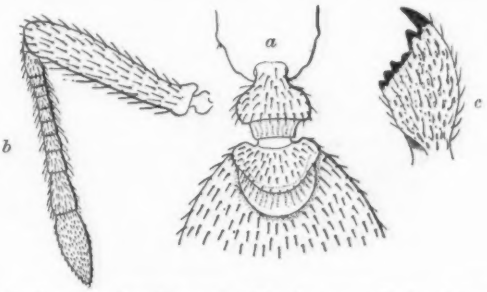

FIG. 4. *Erebomyrma Longii* sp. nov. Female. *a*. pedicel and base of gaster. (dorsal view.) *b*. antenna; *c*. mandible.

edge and the sides of the node ; concave posterior dorsal declivity and the whole ventral surface of the petiole opaque, very finely and densely punctate, the former in addition with indistinct rugæ radiating from the posterior edge of the segment. Postpetiole above in the middle shining, with several round foveolæ, which on the sides become prolonged backwards so that the surface has a somewhat grooved appearance ; lower surface opaque and densely punctate like the lower surface of the petiole. Gaster shining, the segments smooth and very finely and sparsely punctate at their bases but more opaque and evenly reticulate along their distal borders. In addition to this sculpturing there is a small cluster of impressed reticulations around the insertion of each hair. Legs coarsely punctate-foveolate.

Body, except the epinotum, covered with tawny hairs which are relatively shorter than in the worker. On the head, thorax and femora the hairs are erect, on the petiole, postpetiole and gaster suberect, on the antennæ, tibiæ and tarsi shorter and more appressed. Wings covered with minute black hairs.

Male.—(Fig. 5.) Length 5–5.5 mm.

Black; venter and posterior margins of gastric segments fuscous; antennæ whitish but appearing somewhat infuscated on account of a covering of very short black hairs; antennal scape black, second joint paler than the succeeding joints. Mandibles reddish, black only at their bases. Tarsi infuscated from the tip of the first joint. Wings blackened, apical third hyaline; veins and stigma black.

Mandibles longitudinally striated, especially at the base; smooth and shining towards their tips. Clypeus shining in the middle, irregularly and coarsely rugose at its lateral and posterior edges. Head subopaque, with several systems of rather indistinct, parallel rugæ with smooth interrugal spaces; one system runs transversely just behind the clypeus, another on either side from the frontal carina obliquely to the anterior ocellus, where it meets the corresponding series from the other side; another system runs transversely between the two posterior ocelli, while still another is continued downwards from each of these ocelli to the sides and back of the head.

FIG. 5. *Erebomyrma Longii* sp, nov. Male.

Mesonotum subopaque, remainder of thorax smooth and shining except the neck and mesopleuræ which are opaque. Mesonotum with a smooth median band only on its anterior half, the remaining surface more densely covered with elliptical foveolæ than in the female. Metanotum and posterior portion of scutellum with fine parallel transverse rugæ. Mesopleuræ and sides of pronotum sparsely foveolate. Metapleuræ longitudinally rugose. Epinotum almost impunctate. Petiole and postpetiole somewhat roughened and subopaque, node of former smooth and shining, as is also the gaster. The sculpture of the gaster is like that of the female but more indistinct.

Body covered with rather dense, yellowish-gray hairs, which are suberect on the head, thorax and abdomen, but appressed on the legs. There are a few hairs on the shining surface of the epinotum and on the petiolar node. On the antennæ the hairs are microscopic, except on the scape where they are dense and rather conspicuous. Wings covered with minute black hairs.

Described from numerous workers and males and four females from Denton, Denton County, north Texas.

The genus *Erebomyrma* is to be placed in the Myrmicine tribe Solenopsidii, which is known to embrace the following genera: *Solenopsis* Westwood (cosmopolitan); *Diplomorium* Mayr (South Africa); *Aëromyrma* Forel (Madagascar); *Oligomyrmex* Mayr (India, Australia); *Carebara* Smith (Africa, Australasia); *Tranopelta* Mayr (South America); *Lophomyrmex* Emery (India); and *Pheidologeton* Smith (India and Australasia).[1] With the exception of the first and last, these genera are represented each by only one or a few species, and in some cases the sexual forms are imperfectly known. Of *Tranopelta* the workers are unknown, unless the workers from Paraguay mentioned by Mayr (Suedafrikanische Formiciden, 1901, p. 17) as having a distinctly 3-jointed antennal club, 3-jointed maxillary palpi and very small eyes, belong to this genus. In view of these facts a future revision of the tribe Solenopsidii may lead to modifications in the definition of the genera including the one described in this paper. The genera *Aëromyrma*, *Oligomyrmex*, *Pheidologeton* and certain species of *Solenopsis* are characterized by having highly dimorphic workers. In many cases these are connected by a more or less complete series of intermediate forms in the same nest (*e. g.*, *Pheidologeton*, *Solenopsis geminata*). *Erebomyrma* agrees with *Diplomorium*, *Carebara* and most species of *Solenopsis* in having workers of one caste only, and these are extremely diminutive as compared with the males and especially the females. *Erebomyrma* is evidently most closely related to *Solenopsis*, *Diplomorium* and *Aëromyrma*, but differs from the two former in having the epinotum armed and from the latter in having 11- instead of 10-jointed antennæ, and in the absence of any dimorphism in the workers. The latter character is variable, however, since in one genus (*Solenopsis*) it is absent in most of the species, though highly developed in others. The female of *Erebomyrma* is colored and sculptured much like the female of the African *Carebara vidua* Smith, while the male seems to have many points in common with the male of *Tranopelta*. It is probable that *Erebomyrma*

[1] The genus *Melissotarsus* Emery, formerly supposed to belong to this group of genera, is now placed among the Ponerinæ by Emery.

is not a monotypic genus but comprises also several South American species. At least Professor Emery writes me that he has in his collection two species which seem to belong to the new genus. Both of these are represented by female specimens only. One is from Bolivia, the other from Rio de Janeiro.

Comparatively little is known concerning the ethology of the Solenopsidii apart from the genus *Solenopsis*, which has many representatives in Europe and North America. The majority of the species belonging to the tribe, if we except *Pheidologeton* and the larger forms of *Solenopsis*, like *S. geminata*, appear to have certain common ethological traits of more than usual interest. These characters, which were first appreciated by Forel, and constitute one of the many fine discoveries of that able naturalist, are the following:

1. The males and especially the females of the smaller species of *Solenopsis*, the species of *Aëromyrma*, *Carebara*, *Oligomyrmex*, and presumably also of *Tranopelta*, are of very large size compared with the workers. The same is also true of *Pheidologeton* and the polymorphic species of *Solenopsis* when the sexual forms are compared with the most diminutive caste of workers. The relative dimensions of the queens differ, however, considerably in the different genera. Thus in our common North American *Solenopsis molesta* the workers measure 1.5 mm. in length, the females 4.5–5 mm.; while in *Carebara vidua* the worker is hardly larger than that of *S. molesta* (1.5–2 mm.) whereas the female is of gigantic dimensions (23 mm.). The dimensions of *Erebomyrma Longii* lie between these extremes, though much nearer to those of *S. molesta*. The worker is 1.5–2.25 mm. long, the female 8–8.5 mm. If we cube the dimensions in these three species and make due allowance for the fact that the body of the female ant is in each case proportionally much thicker than that of the worker, we have the following roughly approximate ratios between the volumes of the workers and females:

Solenopsis molesta,	1 : 20.
Erebomyrma Longii,	1 : 150
Carebara vidua,	1 : 2000.

These are rather extraordinary dimensions for queens as com-

pared with workers, especially when we reflect that they represent the sterile and fertile extremes of the same sex.[1]

2. The workers of the species in question all have a pale, etiolated appearance, being uniformly yellow or light brown in color, while the huge males and females are deeply and often conspicuously colored. This is noticeably the case with *Carebara* and *Erebomyrma*.

3. The eyes of the workers are vestigial or quite absent (*Carebara*), in marked contrast with the well-developed eyes and ocelli of the males and females.

4. As we should naturally infer from the characters enumerated under 2 and 3, these ants are hypogæic or subterranean, *i. e.*, rarely or never coming to the surface except during the nuptial flight of the deeply colored sexual forms.

5. It is clear that the diminutive workers must be able to obtain large quantities of food, or they could never raise so many and such enormous males and females. From this, again, we may infer that the species prey on other ants or termites, and this inference is supported by observation in all cases where it has been possible to study these ants in their nests. The European *Solenopsis fugax*, the North African *S. latro*, the North American *S. molesta* and *S. texana*, and probably many other small species of the genus, live in the nests of larger ants belonging to different genera and species (*Formica*, *Aphænogaster*, etc.). Here they inhabit small chambers in the walls separating the galleries of the larger species and, escaping notice, probably on account of their minute size and neutral nest-odor, prey upon the helpless and well-fed larvæ and pupæ of their hosts. This mode of life has been recently called "*lestobiosis*" by Forel, who has directed attention to similar habits in *Aëromyrma* and *Carebara*. Sikora found *Aëromyrma Nosindambo* Forel, of Madagascar, as a regular inhabitant in the earthen nests of termites, and Haviland

[1] Other cases comparable to the extreme disproportions of the female and worker *Carebara* are certainly rare but they occur nevertheless in *Pheidologeton* and in *Atta* (*s. str.*). The minimum workers of the Texan *Atta fervens* Say are barely 2 mm. long, whereas the queens measure fully 17 mm. Among some specimens of the Bengalese *Pheidologeton ocellifer* Smith given me by Professor Forel, I find diminutive workers only 2.25 mm. long and a queen of 16 mm. The relative differences in volume in these cases can be approximately computed without difficulty.

found *Carebara vidua* of South Africa also living in lestobiosis in the clay nests of termites (*Termes natalensis*). A consideration of these facts and the taxonomic affinities of *Erebomyrma Longii* led me to surmise that this species too must be lestobiotic, in all probability not with other ants but with some of our Texan termites. That the species is hypogæic would seem to be perfectly clear from Mr. Long's statements quoted in the opening paragraphs of this paper. A second letter, in response to a request urging him to search for termite nests on the spot where he found the *Erebomyrma*, tends to confirm my suspicions of its lestobiotic habits. Mr. Long says: "There seems to be a great number of termites in this vicinity, as I found the sexual forms issuing in great numbers from many holes in my back yard, just like the ants of the new genus which I sent you. Several of these holes were very close to the spot where the ants were captured." During the coming year Mr. Long will endeavor to obtain more definite data concerning the habits of the interesting ant which he has brought to my notice.

AUSTIN, TEXAS,
November 29, 1902.